

MATERIALS PHYSICS AND PROCESSING (MPP)

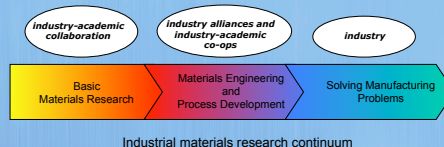
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TECHNIQUES AND CAPABILITIES

- High-throughput, real-time, *in-situ* rapid thermal annealing (RTA) studies of structural changes in thin films, film stacks, and nanopatterned samples:
 - Phase transformations, texture changes, barrier failure, interfacial roughening, *etc.*
- X-ray diffraction (XRD) and scattering techniques on solids, including thin films, stacks, nanopatterned samples, magnetic and strongly correlated systems, and bulk materials. Capability for mounting small environmental chambers, bending jigs, magnets, and Displexes.
 - Resonant scattering, magnetic scattering, pole figures, phase ID, strain, reflectivity, *etc.*



3 Pole Wiggler source
Dual-bandpass monochromator (Si(111) or multilayers)

RTA endstation – high flux

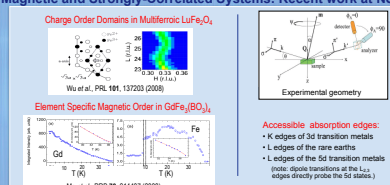
- *in-situ* RTAs to 1100°C
- resistivity
- optical light scattering
- robotic sample handling
- automated/remote control of expt
- linear and area detectors

XRD endstation – high resolution

- six-circle diffractometer
- variable polarization
- 1-Tesla magnet
- small chambers, stages, Displex
- point, linear, and area detectors

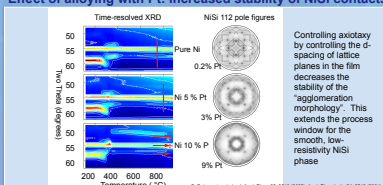
APPLICATIONS

Magnetic and Strongly-Correlated Systems: Recent work at NSLS



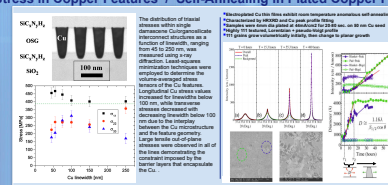
Resonant and non-resonant x-ray scattering (XRS) will be used to study electronic ordering phenomena such as magnetic, orbital, charge, and multipole order. Nonresonant XRS is well-suited to characterize the weak lattice distortions that often accompany electronic ordering, while resonant XRS is element specific and provides additional information through measurements of energy, polarization, and azimuthal dependencies.

Effect of alloying with Pt: increased stability of NiSi contacts



Real-time, *in-situ* annealing is used to study phase transformation sequences and kinetics of materials used in chip manufacturing and those being developed for future devices, such as Phase-Change Memory. Texture and strain also play an important role in device performance. Pole figures are particularly useful for understanding the behavior of metal silicides used as electrical contacts to the device layer in chips.

Stress in Copper Features / Self-Annealing in Plated Copper Films



High-resolution XRD is a valuable technique for determining stress/strain, grain size, lattice defects, and other structural subtleties that can strongly affect the behavior of chip components. BEOL (back-end-of-the-line) processes such as metal deposition, trench lining and capping, dielectric formation, chemical-mechanical polishing, and annealing can all lead to mechanical and chemical effects that require in-depth structural characterization.

SPECIFIC PROJECTS / ADDITIONAL INFORMATION

RTA end station sample handling

IBM-GlobalFoundries "Feynman" Test Site

3mm x 5mm sections

- Phase Formation
- Texture
- Stress

Width = 15 mm
Length = 50 mm
Pitch = 1.20 um

Full texture determination

Linear detector
600 simultaneous measurements

Cylinder or video of pole figure

6 hours → 640 pole figures

- Rapid switching between the RTA and XRD endstation hutches and between high-flux and high-resolution monochromator crystals will enable the efficient use of beam time.
- IBM currently is developing an automated RTA endstation for the CLS that will enable remote operation and fast turnaround.
- The NSLS has plans for a unique 1 Tesla magnet that can be mounted on a standard Huber diffractometer (see figure 2 above).
- IBM has a new test site that uses EUV lithography to make samples having arrays of nanometer-scale features for measuring scaling effects on phase formation, stress, and texture.
- IBM is collaborating with students at E. Poly Montreal and U. Ghent to develop software for sophisticated texture measurement and analysis.